T.O. 37C2-8-36-1

TECHNICAL MANUAL

OPERATION AND MAINTENANCE INSTRUCTIONS

STORAGE TANK, LIQUID OXYGEN
TYPE TMU-20/E, 5000 GALLON CAPACITY
PART NO. 112220
NSN 3655-01-252-1257

CRYENCO, INC.

(F41608-86-D-0279)

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FOREWORD/PREFACE

Purpose. This technical manual will provide the using activity with operation and maintenance instructions for the 5000 gallon Liquid Oxygen Storage and Transfer Tank, Type TMU-20/E.

Scope. This manual will provide the using activity with applicable information required on specifications, theory of operations, operating procedures, cleaning, inspection, removal and replacements of the service line filter, troubleshooting, and tank testing associated with the use of cryogenic equipment and products. Any corrections regarding this technical manual should be submitted in accordance with T.O. 00-5-1.

Throughout this manual the unit will primarily be called the Tank. It may also be called Storage Tank. Tanks referenced but not covered by this manual will contain additional descriptions. Example: supply tank and receiving tank. Liquid oxygen may be referred to as the product or abbreviated as LOX in parts of this manual.

SAFETY SUMMARY

The following are general safety precautions and instructions that people must understand and apply during many phases of operation and maintenance to ensure personal safety and health and the protection of Air Force property. Portions of this may be repeated elsewhere in this publication for emphasis.

WARNING AND CAUTION STATEMENTS

WARNING and **CAUTION** statements have been strategically placed throughout this text prior to operation or maintenance procedures, practices or conditions considered essential to the protection of personnel (**WARNING**) or equipment and property (**CAUTION**). a **WARNING** and **CAUTION** will apply each time the related step is repeated. Prior to starting any task, the **WARNINGS** or **CAUTIONS** included in the text for the task will be reviewed and understood.

QUALIFIED PERSONNEL

Only qualified personnel shall be authorized to operate and perform maintenance on this equipment.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

If unique local conditions make compliance with the protective clothing or other occupational health requirements specified in this manual unnecessary or impractical, obtain an evaluation of the operation from the Bioenvironmental Engineer. The Bioenvironmental Engineer and Base Safety Office will determine the required precautions.

KEEP AWAY FROM ABSORBENT MATERIALS

Liquid oxygen must be kept away from absorbent materials such as rags, wood, paper, and clothing. These materials may trap the oxygen gas and later be ignited by any source of spark or flame.

KEEP AWAY FROM HYDROCARBONS

Liquid oxygen is not compatible with hydrocarbons. Forms of hydrocarbons are oils, greases, gasoline, tar, and asphalt. Liquid oxygen in contact with hydrocarbons presents a severe explosive hazard. The equipment, its components, and tools used in maintenance must be kept free of hydrocarbons.

SMOKING

Do not smoke or permit smoking within fifty (50) feet of Tanks in liquid oxygen service. Do not carry sources of flame in the vicinity of Tanks in liquid oxygen service. Use caution in smoking immediately after being exposed to liquid oxygen vapors as these vapors may be still trapped in clothing.

BODILY CONTACT

Never allow liquid oxygen or the cold piping on the equipment to contact the skin. The extremely low temperatures created by liquid oxygen will immediately freeze the body area and result in severe frostbite.

SAFETY SUMMARY--CONT.

EMERGENCY TREATMENT OF BODILY CONTACT

In the event of bodily contact with liquid oxygen or the tank piping, remove the victim from the exposure immediately. Do not attempt to rewarm any body part as this should be accomplished by proper medical personnel. Transport the patient to an emergency room of a hospital or clinic as soon as possible. Keep the patient dry and warm enroute to the emergency room. Upon arrival, identify the injury as exposure to liquid oxygen.

UNAUTHORIZED CONTAINERS

Never put liquid oxygen in any container without proper safety devices (e.g. thermos bottle). When heated, liquid oxygen will expand rapidly and build pressures to extremely high levels. The results of pressure buildup without safety devices may result in an explosion.

VENTILATION

Adequate ventilation must be provided for personnel for tank functions such as transfer operations, filling, draining, purging, painting, welding, brazing, and cleaning.

LIFTING

Equipment used in lifting and moving the tank must be of sufficient rating to handle the weights involved.

PART CLEANLINESS

All parts used in liquid oxygen service must be kept clean and free of hydrocarbons. Never use shop air to dry cleaned parts. Ultraviolet lights are used to check parts that have been cleaned. Overexposure to ultraviolet light can result in conjunctivitis (inflammation of the inner eyelid and eyeball) and possible skin burns which could result in skin cancer. Common hardware components not properly packaged that come in contact with liquid or gaseous product, shall be properly cleaned prior to use.

PURGING

When purging a tank, all piping and valves become hot enough to burn. Ensure tank components are at ambient temperatures before attempting handling or removal after purging operations.

PURGE AND SPLASH HAZARDS

When discharging cryogenic liquids from service hoses, blow down lines or drain valves, open the valves slowly to avoid being splashed by the cryogenic product.

WELDING AND BRAZING

Welding or brazing operations produce heat, metal fumes, injurious radiation, metal slag, and airborne particles. Proper protective equipment must be worn before welding or brazing. Never look directly at the arc when welding or the flame during brazing. Never attempt welding or brazing operations near Teflon components (e.g. anti-seize tape). Teflon components deteriorate at high temperatures and emit poisonous gases. Proper ventilation is a must when welding or brazing.

SAFETY SUMMARY--CONT.

TANK VACUUM

Never break the vacuum to air in the annular space, with or without liquid in the tank. The liquid must be drained and the tank warmed to ambient temperature. Break the vacuum to dry nitrogen gas.

CLEANERS/CHEMICALS/PAINTS/PRIMERS

Some cleaners, chemicals, paints, and primers have adverse effects on skin, eyes, and the respiratory tract. Observe manufacturer's Warning labels; Material Safety Data Sheet (MSDS) instructions for proper handling, storage, and disposal; and current safety directives. Use only in authorized areas. Unless otherwise indicated in the text, use as described in this TO should not result in any immediate health concerns. Consult the local Bioenvironmental Engineer and Base Safety Office for specific protection equipment and ventilation requirements.

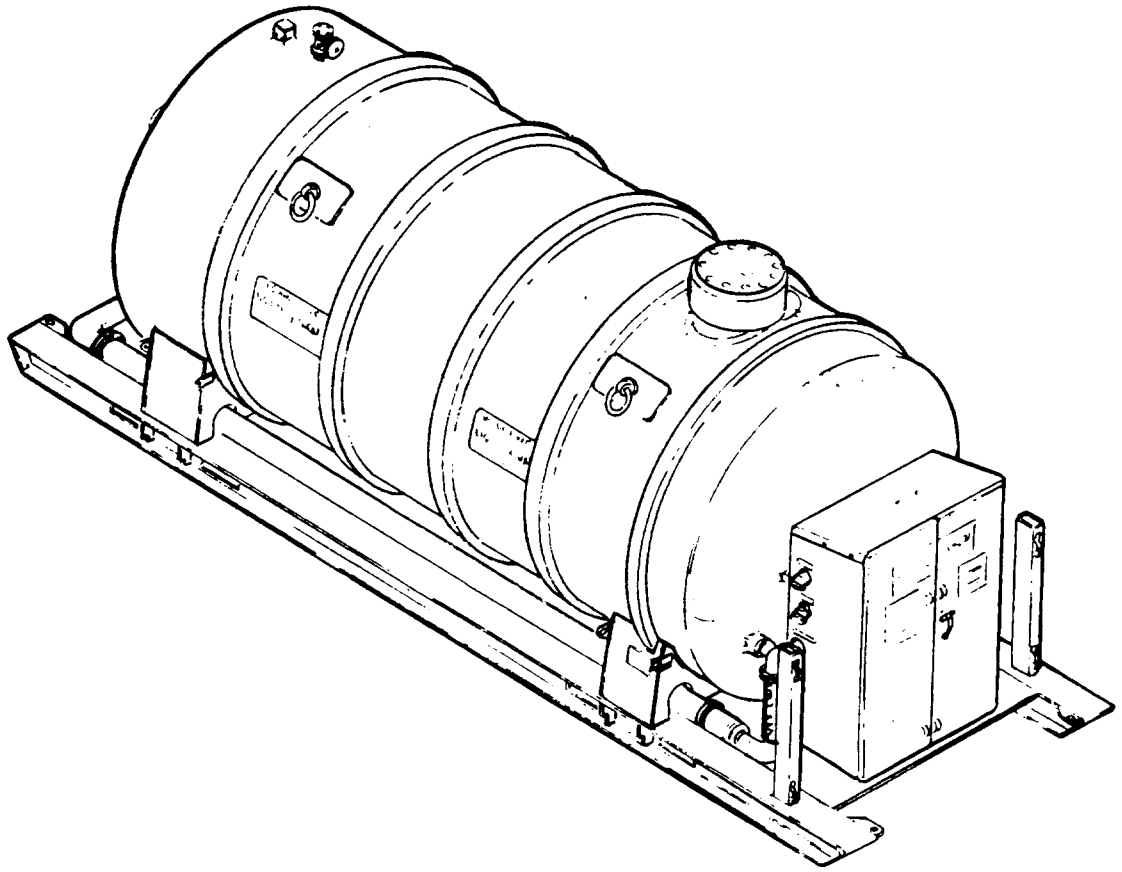


Figure 1-1. Tank, Storage, Liquid Oxygen, Type TMU-20/E.

SECTION 1
INTRODUCTION AND GENERAL INFORMATION

1-1. INTRODUCTION.

1-1.1. Purpose. The purpose of this technical manual is to provide instructions for the operation and maintenance of the 5000-gallon Liquid Oxygen Storage and Transfer Tank, Type TMU-20/E, part number 112220, manufactured by Cryenco, Inc., Denver, Colorado. (See Figure 1-1).

1-1.2. Scope. The manual contains operation and maintenance information. The information provided is pertinent to organizational level for operational use, and organizational and intermediate level for maintenance activities. These activities are limited to the use of common tools, test equipment, authorized spare parts, and those special tools and test equipment listed in this manual.

1-1.3. Arrangement. Section I of this manual describes the main features and leading particulars of the tank. Section II describes the special tools and test equipment required for operation and maintenance of the tank. Section III provides information for preparing the tank for use and shipment. Section IV covers the theory of system operation and operating procedures. Section V describes system inspection, checkout, troubleshooting, and service and replacement of authorized components/subassemblies. Throughout this manual, the unit will be called the storage tank. Liquid oxygen may be abbreviated as "LOX" in parts of this manual.

1-2. GENERAL INFORMATION.

1-2.1. Purpose of the Storage Tank. The purpose of this storage tank type TMU-20/E, is to store liquid oxygen and dispense it to other systems.

1-2.2. Description of the Storage Tank.

1-2.2.1. Physical Description. The storage tank (figure 1-1) is skid mounted and consists of an inner tank suspended inside an outer tank or jacket. The inner tank is wrapped with layers of insulation and is separated from the outer tank by a vacuum....like a large thermos bottle. The control housing, at the front of the storage tank, protects the valves, indicators, and other controls for the tank. The pressure buildup coil is routed around both sides and rear end of the tank and acts as a heat-exchanger, where the liquid product is converted to gas, providing the vapor pressure to the storage tank. The tank has a manway to permit entry for cleaning and inspecting the interior of the inner shell without breaking the annular space vacuum. The following main component descriptions, together with the descriptions in Table 1-2 provide more detailed physical and functional data covering the storage tank.

1-2.2.2. Liquid Level Gage. The liquid level gage directly indicates the level of liquid oxygen or liquid nitrogen (dual side) in the inner storage tank. The gage is calibrated in gallons (0 to 5000 gallons). Safe operating level up to 5000 gallons is indicated in green.

1-2.2.3. Pressure Gage. The pressure gage indicates the pressure in the inner storage tank. The gage is calibrated to read from zero to 100 psig. Safe operating pressure of 0 - 50 psig is indicated by a green band on the gage face. Unsafe pressure of 50-100 psig is indicated by a red band.

1-2.2.4. Piping System. The piping system consists of a fill/drain line for filling and draining the storage tank, a service line for servicing other systems, a vent system for overboard venting of excess liquid or gas, and a pressure relief valve system which is connected to the vent piping system. Devices provided to control these sub-systems are described in the operation portion of this manual.

1-2.3. Properties of Liquid Oxygen. Liquid oxygen is a pale blue nonviscous, waterlike fluid. Liquid oxygen boils at -183° Centigrade (-299°F). At atmospheric pressure it is 1.14 times heavier than water and weighs 9.527 pounds per gallon. Liquid oxygen when converted to gaseous oxygen at ambient temperature and expands to about 860 times its original volume. One cubic foot of liquid oxygen (7.48 gallons) expands to about 860 cubic feet of gas at 21° Centigrade (70°F) and sea level pressure.

Liquid-to-gas at atmospheric pressure is:

LIQUID OXYGEN	GASEOUS OXYGEN
At -183°C (-297°F)	At 21°C (70°F)
1 liter (.26 gallon)	30.4 cubic feet
3.78 liters (1 gallon)	115 cubic feet
5 liters (1.3 gallons)	152 cubic feet
25 liters (6.6 gallons)	760 cubic feet

1-2.4. Tank Management. This tank is classified as FSC 3655 registered Air Force ground support equipment. It is to be managed under provisions of AFR 66-1. Using activities will record the USAF registration number located on the tanks data plate. The USAF registration number consists of a 13 digit, alpha-numerical arrangement which indicates: (1) The Federal Supply Class, (2) Calendar year in which the tank was built, (3) Federal Item Identification Number (FIIN), and (4) Assigned serial number. When the serial number consists of fewer than four digits, zeros will be added in front of the serial number. Example: Cryenco, Inc. manufactured tanks, type TMU-20/E, NSN 3655-01-252-1257 and delivered in 1991 with serial number beginning with 0001. The Federal Item Identification Numbers assigned to tanks is "EAR" for LOX. The sample registration number, therefore, would be "3655-91-EAR-0001". Compliance with the afore stated instructions shall be reported in accordance with AFM 66-1 and T.O. 00-25-215.

1-2.5. Leading Particulars. A summary of leading particulars for the storage tank is listed in Table 1-1.

1-2.6. Related Publications. The publications listed in Table 1-2 are used in conjunction with this manual to perform the operation and maintenance procedures.

1-2.7. Special Clothing. During all operations, wear gloves and face shields as specified in T.O. 00-25-172. If in doubt, consult your Safety Officer.

1-2.8. Consumable Materials List. Materials used in the maintenance of the storage tank at the operating level are listed in Table 1-3.

Table 1-1. Leading Particulars

General Information	
Identification	Liquid Oxygen Storage Tank, Type TMU-20/E
Manufacturer	Cryenco, Inc., Denver, Colorado
Part Number	112220
National Stock Number	NSN 3655-01-252-1257
Capacity:	
Gross Volume	5100 gallons
Net Volume	5000 gallons
Weight:	
Empty	25,000 Pounds
Full	68,750 Pounds
Evaporation Rate	Less than 120 lbs. of liquid oxygen per 24 hours.
Over-All Dimensions	
Length	300 inches
Width	96 inches
Height	120 inches
Inner Vessel	
Design and Fabrication Criteria	Section VIII of ASME Code
Type	Cylindrical Vessel, 304 Stainless steel welded construction with torispherical heads.
Operating Pressure (Max.)	50 psig
Outer Vessel	
Type	Cylindrical Vessel, carbon steel welded construction, and torispherical heads
Insulation	
Type	Multi-layer (incorporating aluminum/reflective radiation barriers, glass paper) and vacuum.
Manual Control Valves	
Type	Bronze-body, globe valve with replaceable body seat, Teflon packing and KEL-F disc. Extended stainless steel stem.
Leakage	Not to exceed 2 cubic inches of free air, or oxygen gas per hr. per inch of valve nominal size.

Table 1-1. Leading Particulars--Cont.

Filters	
Type	In-line stainless steel wire mesh element fused to filter housing.
Rating	10-micron nominal, 25-micron absolute.
Tank Relief Valve	
Type	Bronze-body cryogenic safety relief valve. Stainless steel spring, special Teflon seat. Meets ASME Boiler & Pressure Vessel Code, Section VIII requirements. 2-inch IPS inlet and 2½-inch IPS outlet. Set at 60 ±5 psig.
Rupture Disc Assembly	
Type	Union, with 2-inch inlet and outlet. Rated at 91 $^{+9}_{-5}$psig.
Pressurization (Pressure Buildup) Coil	
Type	Exposed tube heat-exchanger coil
Line Relief Valves	
Type	Inlet pop-type, 75 ±5 psig.
Liquid Level Indicator	
Type	0-5500 gallon, differential pressure (single bellows), dual scale (oxygen and nitrogen)
Tank Pressure Indicator	
Type	0-100 psig. Bourdon tube type.
Vacuum Indicator	
Type	Thermocouple (FSN 6685-00-877-9593)
Connections	
Fill/drain Couplings	3½-inch male LOX (per USAF Dwg. 8991187).
Service Hose Couplings	1-inch female LOX (per USAF Dwg. 8991174).
Vacuum Seal-Off	1¼-inch, 150 lb. stainless steel flange.
Vapor Vent Discharge	3-inch female pipe thread (NPT)
Service Hose	
Type and Dimensions	1-inch ID x 10 Feet. Liquid oxygen transfer (per USAF Dwg. 59C6671-2)

Table 1-2. Related Publications

Publication No.	Title
T.O. 00-25-172	Ground Servicing of Aircraft and Static Grounding/Bonding
MIL-STD-1359	Cleaning Methods and Procedures for Breathing Oxygen Equipment
T.O. 37C2-8-36-3	5000 Gallon Liquid Oxygen Storage Tank, Overhaul Instructions
T.O. 37C2-8-36-4	5000 Gallon Liquid Oxygen Storage Tank, Illustrated Parts Breakdown
T.O. 37C11-3-1	Vacuum Gage (Portable), Part No. 15840
T.O. 37C2-8-1-127	Liquid Oxygen/Nitrogen Overboard Vent System
T.O. 37C2-8-1-116WC-1	Inspection Work Cards
T.O. 00-25-107	AFLC Area Support
T.O. 00-25-223	Integrated Pressure Systems and Components
T.O. 00-25-252	Certification of USAF Aircraft and Missile Welders
T.O. 00-25-229	Valves and Regulators
T.O. 35-1-3	Painting and Marking of USAF Aerospace Ground Equipment
T.O. 33D2-10-60-1	Cryogenic Sampler

Table 1-3. Consumable Materials List

Material	Specification	Federal Stock Number
Tape, Antiseize	MIL-T-27730	8030-00-889-3535 (1/2 inch)
Nitrogen	BB-N-411	6830-00-285-4769
Leak Detection Compound, Oxygen Systems, Type 1	MIL-L-25567	6850-00-621-1820
Solvent, trichlorotrifluoroethane	MIL-C-81302	6850-00-681-5688
Tag	UU-T-81	
Pressure Sensitive Tape	PPP-T-60	

SECTION II
SPECIAL TOOLS AND EQUIPMENT

2-1. GENERAL.

Special tools and equipment required to operate and maintain the storage tank are listed in Table 2-1 and shown in Figures 2-1 and 2-2. Items recommended are approved tools and test equipment if available. However, equivalent items may be used if recommended equipment is not available.

Table 2-1. Special Tools and Equipment

Tool/Equipment Number	Figure Number	Nomenclature	Use and Application
Part No. 15840 NSN: 6685-00-115-9602YD	2-1	Vacuum Gage	Determine Annulus Vacuum
Part No. 50C-0016-2 NSN: 6685-01-117-9913YD	2-2	Dual Efficiency Meter	Check boil-off rate to determine efficiency of annulus vacuum

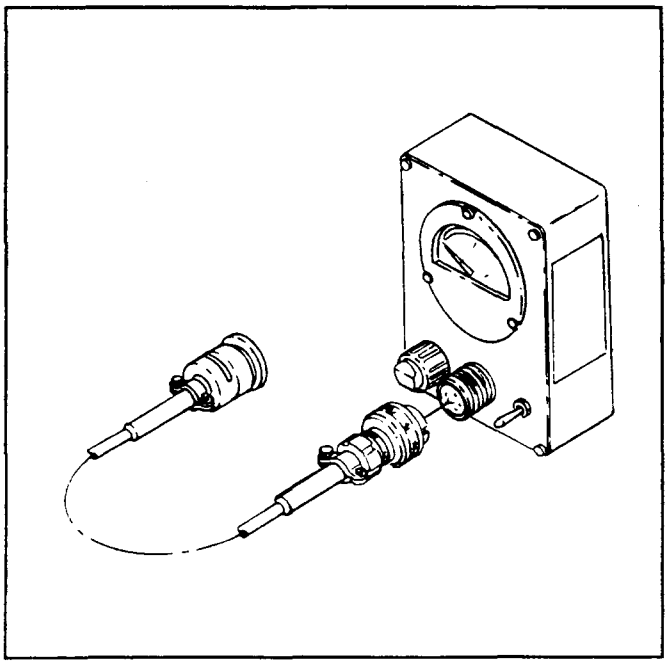


Figure 2-1. Vacuum Gage

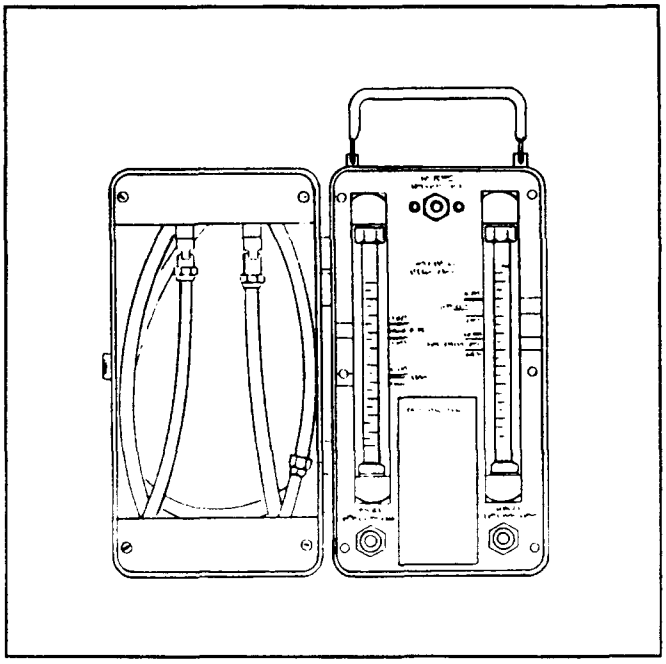


Figure 2-2. Dual Efficiency Meter

SECTION III
PREPARATION FOR USE, STORAGE AND SHIPMENT

3-1. SCOPE.

This section describes the tasks, adjustments, inspections, and precautions necessary to prepare the storage tank for use, storage or shipment empty or filled.

3-2. PREPARATION FOR USE.

3-2.1. When Received from Factory. The storage tank is shipped from the manufacturer with the inner tank pressurized with 10-20 psig of clean, dry, oil-free nitrogen gas. All valves are closed, and the discharge vent is sealed with pressure sensitive tape. Relief valves will be covered, and the control housing covered with a protective shield. The annular space, between the inner and outer tanks, has been evacuated to the desired vacuum. All packing covers must be removed, and the entire unit given a basic inspection before use.

3-2.2. When Re-Filling. When re-filling, tanks will usually have a positive pressure caused by liquid remaining in the tank. A basic inspection should be performed on each storage tank before filling. Pay particular attention to valves and vents. Always suspect contamination in cases where valves have been left open during shipment.

3-2.3. Inspection. The storage tank is given a complete operational and visual inspection before being shipped from the manufacturer. However, it amust be inspected each time that it is received, removed from dry storage, and before being placed in service.

a. Inspect the outside of the storage tank, all valves and piping for any damage that might affect performance or safety.

b. Check all valves for smooth positive action. Make sure that the valves of empty tanks are closed tightly.

CAUTION

Empty storage tanks returned for refilling with valves open must be considered contaminated. Failure to purge tank may cause damage to equipment.

c. If storage tank is contaminated, purge before filling. Refer to T.O. 37C2-8-36-3 for purging procedures.

d. Check all welds for indications of cracks.

e. Inspect the outer jacket for rust or corrosion.

WARNING

Failure to verify that the vapor vent connection is unplugged and clear could cause severe personal injury and/or equipment damage.

f. Make sure that all couplings and openings are clean and free from obstructions.

g. Remove any oil, grease or other hydrocarbons from the outside of the storage tank with trichlorotrifluoroethane (MIL-C-81302). Observe safety precautions when using solvents.

3-2.4. Location.

3-2.4.1 Selection of an Operating Site. Publications used in establishing proper locations for liquid oxygen tanks are listed in Table 1-2.

3-2.4.2 Type Site. To avoid the accumulation of oxygen vapors from leakage and venting, the tank shall be located in a well ventilated area. The tank will be placed on a permanent or semi-permanent location with a smooth, level foundation for proper operation. A concrete surface of sufficient size to accomodate transfer operations by delivery vehicles shall be utilized.

3-3. PREPARATION FOR STORAGE AND SHIPMENT.

Make sure that storage tanks to be stored or shipped

have been totally drained of all liquid product (Refer to Section IV) and purged (Refer to T.O. 37C2-8-36-3). Following purging, pressurize the inner tank to 10-20 psig. of clean, dry, oil-free nitrogen gas (Refer to T.O. 37C2-8-36-3). All valves leading to the inner vessel (V-3, V-4, V-5, V-6, V-7, V-8, V-9) Figure 4-1) must be tightly closed. Storage tanks containing liquid product are not transportable.

3-3.1. Empty Storage (Long Term).

a. Thoroughly clean the exterior of the storage tank. All loose or chipped paint, solvents, and hydrocarbons must be removed.

b. If necessary, repaint the storage tank in accordance with T.O. 35-1-3.

c. Replace all defaced or damaged decals.

3-4. LIFTING AND MOVING THE STORAGE TANK (See Figure 3-1).

Tank is only to be moved when empty. The tank can be lifted and moved by two (2) methods as follows:

CAUTION

Do not jerk or drop the tank during any lifting and moving operation. Tank could be damaged.

3-4.1. Crane Lifting. When using a crane for lifting and moving the tank, the lifting assemblies (e.g. slings, cables, or chains) shall have a sufficient rating for the tank weight (25,000 pounds) and G-loads generated by the tank weight. The following are minimum requirements for lifting assemblies:

a. The minimum length of EACH lifting assembly shall be 120 inches in length from the lifting eye to the point of lifting.

b. The minimum rating of EACH lifting assembly shall be 25,000 pounds. This requirement is based upon the tension on each lifting assembly of 25,000 pounds at two (2) G's (1 G is equal to the weight of the tank).

If lifting assemblies of minimum requirements are not available, then a combination of components to meet the minimum requirements is acceptable. Each component must meet the minimum requirements. Attach the lifting assemblies to the top lift rings on the sides of the tank. If a spreader bar is to be used, make sure its rating is sufficient for the weight involved.

3-4.2. Forklift Lifting. When using a forklift for lifting and moving the tank, the lifting capacity of the forklift must be sufficient for the weight of tank (25,000 pounds). If a single forklift of sufficient capacity is not available, then a combination of forklifts may be used if the combined lifting capacity is adequate for the weight involved. Four forklift slots have been provided in the skid frame on each side of the tank. Make sure the forklift tines are fully inserted in two of these slots before attempting to lift the tank. Maintain the tank in a horizontal position during lifting and moving the tank.

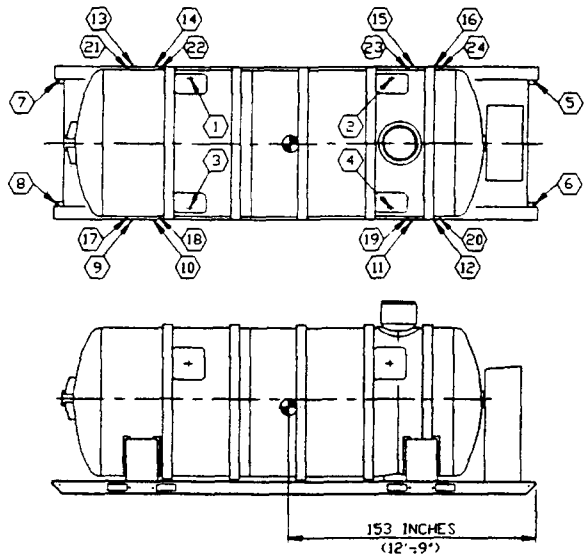
3-4.3. Tiedown. The twenty (20) tiedown attachment locations on the skid base shall be used to secure the tank during transportation. The equipment must be restrained in 5 specified directions as follows:

Direction	"g" Loading	Total Load
Fore	3.0	75,000 pounds
Aft	1.5	37,500 pounds
Lateral	1.5	37,500 pounds
Up	2.0	50,000 pounds
Down	4.5	112,000 pounds

3-5. STATIC GROUNDING.

3-5.1. Grounding Requirements. Prior to designated operations, the tank shall be grounded against the effects of static electricity reference T.O. 00-25-172 (see figure 3-2).

TRANSPORTATION DATA



TRANSPORT ONLY WHEN TANK IS EMPTY

	NO. CABLES	CABLE RATING	ATTACHMENT POINTS	ANGULAR DISPLACEMENT
LIFTING,SINGLE POINT	4 EA	25,000#	1,2,3,4	120° MIN CABLE LENGTH
PULLING,SINGLE POINT	2 EA	25,000#	5,6 OR 7,8	120° MIN CABLE LENGTH
SHIPPING RESTRAINT FORWARD	10 EA	10,000#	5,6,9,10,11,12,13,14,15,16	15° MAXIMUM
AFT	10 EA	10,000#	7,8,9,10,11,12,13,14,15,16	15° MAXIMUM
SIDE	8 EA	10,000#	9,10,11,12,13,14,15,16	15° MAXIMUM
DOWN	8 EA	10,000#	17,18,19,20,21,22,23,24	29° MAXIMUM

Figure 3-1. Lifting Instructions.

NOTE: THESE ARE ALTERNATE METHODS
OF GROUNDING

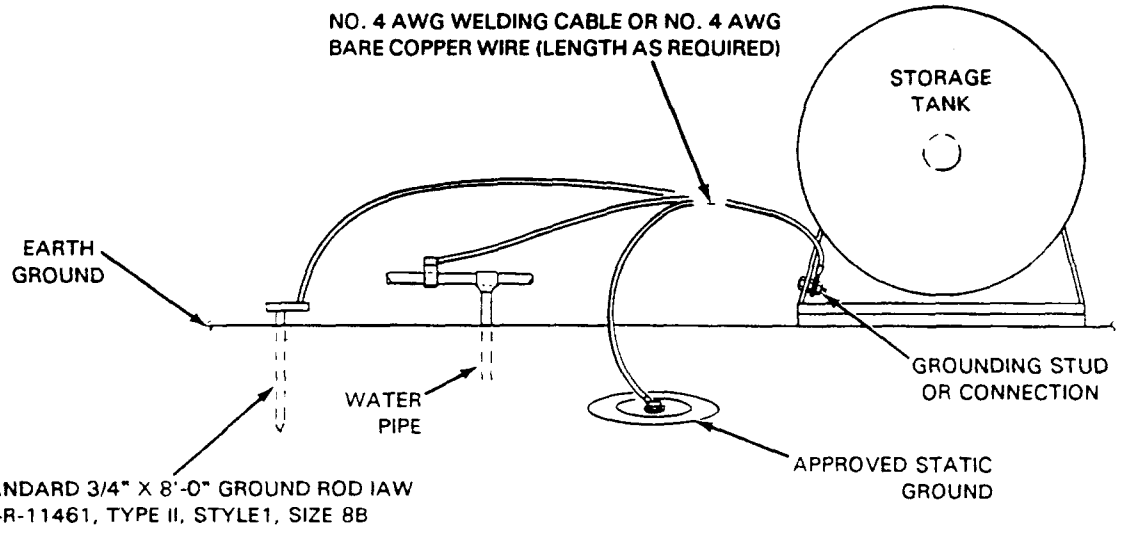


Figure 3-2. Approved Method for Static Grounding

SECTION IV
OPERATION INSTRUCTIONS

4-1. THEORY OF OPERATION

The tank is a self-contained, skid mounted unit designed to be filled with the product LOX, store the product until needed, and transfer the product to smaller aircraft servicing tanks. The design incorporates two (2) shells with the inner shell suspended inside the outer shell. The inner shell contains the product and the outer shell protects the insulation and provides an annular space for vacuum which is also called the annular space. The annular space provides a heat barrier to prevent the loss (boil off) of product within the inner shell.

Transfer of product is accomplished by use of a pressure difference. The pressure required for transfer operations is created by the pressure buildup coil (PBU). The PBU acts as a heat exchanger which changes liquid product into gas through vaporization. The gaseous product fills the area within the inner shell above the liquid product thereby creating positive pressure for product transfer. When the inner shell pressure is greater than the receiving tank pressure the physical requirements exist for product transfer. See paragraph 4-2.3 for purpose and use of each component.

4-2. OPERATING INSTRUCTIONS.

4-2.1. Basic Instructions. All operating controls appear in Figure 4-1, and the basic valve positions for each function are shown in Table 4-1. Equipment controls are described in paragraph 4-2.3. Safety precautions concerning handling of liquid oxygen are described in paragraph 4-2.2. Figure 4-1 shows each component location. However, there is a procedure to be followed for each function, and the sequence for each is outlined in the following paragraphs 4-2.4. through 4-2.7.

4-2.2. Safety Precautions. Only qualified personnel will be authorized to operate the storage tank. All safety precautions must be followed. Protective clothing must be worn during transfer operations. Read and observe the Safety Summary of precautions in the front of this manual. If unsure of any safety requirements, consult your Safety Officer.

4-2.3. Equipment Controls and Indicators. (Figure 4-1).

4-2.3.1. Service Line Valve (V-3). The purpose of V-3 is to start and stop the flow of product through the servicing line. V-3 is used by the operator when servicing receiving tanks to start, control and stop the flow of product.

4-2.3.2. Fill/Drain Line Valve (V-6). The purpose of V-6 is to start and stop the flow of product through the fill/drain coupling. V-6 is used by the operator when filling or draining the storage tank to start, control, and stop the flow of product in or out of the storage tank.

4-2.3.3. Pressure Buildup Valve (V-7). The purpose of V-7 is to allow liquid product to flow to the pressure buildup coil. V-7 is used by the operator during tank operation for building pressure within the inner shell. Once the operating pressure for the inner shell is obtained, V-7 is used to restore pressure losses that occur during tank operations.

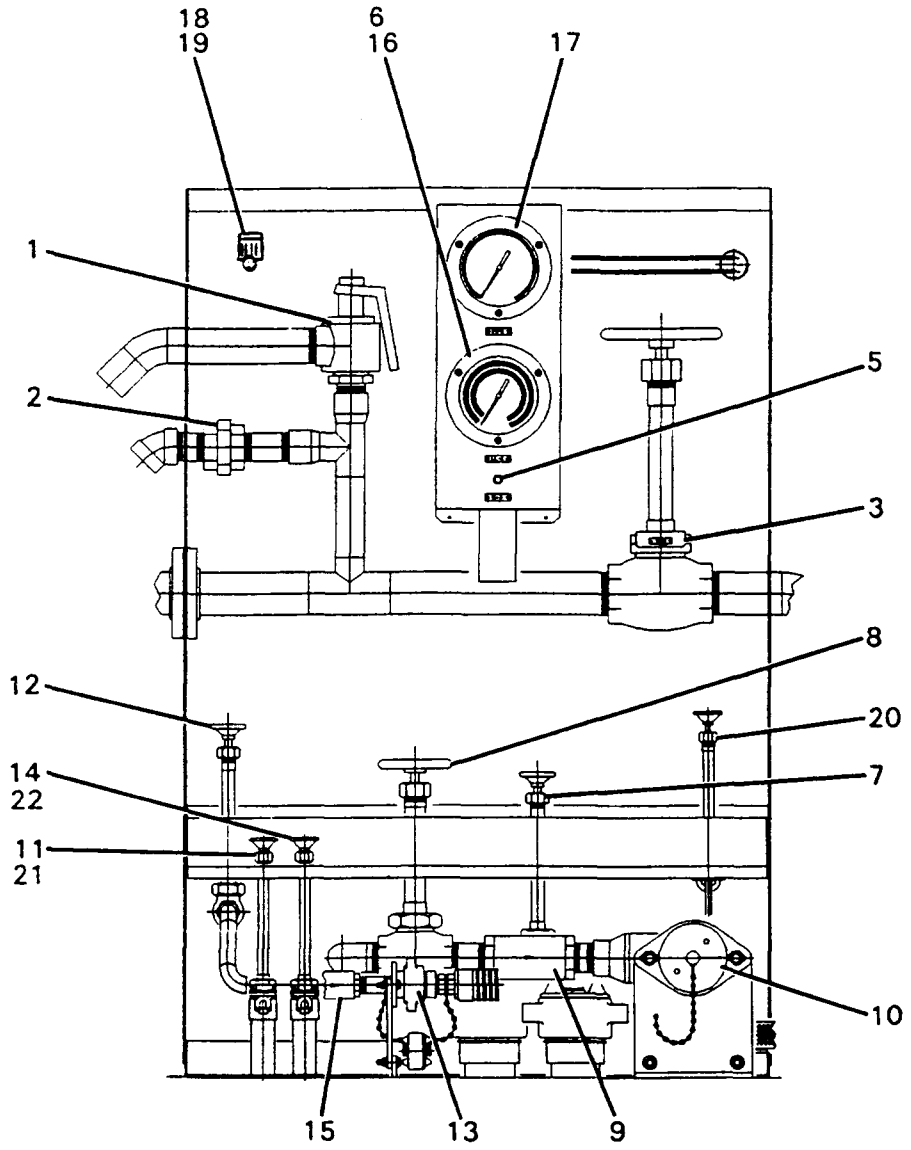
4-2.3.4. Vapor Vent Line Valve (V-8). The purpose of V-8 is to vent gaseous product from within the inner shell. V-8 is used by the operator during tank operations for relieving inner shell pressure which exceeds the normal acceptable operating pressure.

4-2.3.5. Liquid Level Gage (LL-1). The purpose of LL-1 is to indicate the amount of liquid product in the inner shell. LL-1 is used by the operator during tank operations to determine that the inner tank has the proper level of liquid product.

4-2.3.6. Pressure Gage (PI-1). The purpose of PI-1 is to indicate the pressure in the inner shell. PI-1 is used by the operator during tank operations to determine that the inner tank has the proper pressure for the operation.

4-2.3.7. Service Line Vent Valve (V-4). The purpose of V-4 is to drain (vent) liquid trapped in the service line.

4-2.3.8. Fill/Drain Line Vent Valve (V-5). The purpose of V-5 is to drain (vent) liquid trapped in the fill/drain line.



LEGEND

1. Inner Shell Relief Valve (RV-3)
2. Inner Shell Rupture Disc (SD-1)
3. Vent Line Shut-off Valve (V-8)
4. Deleted
5. Pressure Sensing Tap (C-3)
6. Isolation Valve (V-10)
7. Pressure Buildup Control Valve (V-7)
8. Fill/Drain Line Shutoff Valve (V-6)
9. Fill/Drain Line Filter (F-2)
10. Fill/Drain Line Coupling (C-2)
11. Fill/Drain Line Vent Valve (V-5)
12. Service Line Shutoff Valve (V-3)
13. Service Hose Connector, (C-1)
14. Service Line Vent Valve (V-4)
15. Service Line Filter (F-1)
16. Liquid Level Gage (LL-1)
17. Tank Pressure Indicator Gage (PI-1)
18. Vacuum Thermocouple Isolation Valve (V-2)
19. Vacuum Indicator Thermocouple (VI-1)
20. Full Trycock Valve (V-9)
21. Fill/Drain Line Relief Valve (RV-2)
22. Service Line Relief Valve (RV-1)
23. Evacuation Valve (V-1) (Not Shown)
24. Outer Shell Rupture Disc (SD-2) (Not Shown)

Figure 4-1. Operating Controls and Indicators.

4-2.3.9. Service Line Relief Valve (RV-1). Relief valve (RV-1) is used to reduce the hazards to personnel and hardware if pressure in the service line exceeds design parameters. RV-1 protects against the sudden expansion of liquid product trapped in the service line.

4-2.3.10. Fill/Drain Line Relief Valve (RV-2). Relief valve (RV-2) is used to reduce the hazards to personnel and hardware if pressure in the fill/drain line exceeds design parameters. RV-2 protects against the sudden expansion of liquid product trapped in the fill/drain line.

4-2.3.11. Inner Shell Relief Valve (RV-3). Relief valve (RV-3) is used to reduce the hazards to personnel and hardware if pressure in the inner tank exceeds design parameters. RV-3 protects against over pressure conditions in the inner tank.

4-2.3.12. Inner Shell Rupture Disc (SD-1). Rupture disc (SD-1) is used to reduce the hazards to personnel and hardware if pressure in the inner tank exceeds design parameters and the inner shell relief valve (RV-3) fails. SD-1 protects against over pressure conditions in the inner tank.

4-2.3.13. Outer Shell Rupture Disc (SD-2). The purpose of SD-2 is to reduce the hazards to personnel and hardware if pressure in the annular space exceeds design parameters. SD-2 protects against over-pressure conditions in the annular space.

4-2.3.14. Vacuum Isolation Valve (V-2). The purpose of V-2 is to isolate vacuum indicator (VI-1) from the annular space when not in use.

4-2.3.15. Vacuum Indicator (VI-1) (Thermocouple). Vacuum indicator (thermocouple) (VI-1) is used to provide testing of the annular space absolute pressure.

4-2.3.16. Evacuation Valve (V-1). The purpose of V-1 is to provide isolation for the annular space of the outer shell. It also provides a port to connect the vacuum line when evacuating the annular space.

4-2.3.17. Liquid Level Gage Isolation Valve (V-10). The purpose of V-10 is to isolate liquid level gage (LL-1) when repair is needed on gage.

4-2.3.18. Full Trycock Valve (V-9). The purpose of V-9 is to give visual assurance of complete filling of the storage tank. V-9 is open during tank filling to allow liquid to flow overboard indicating tank is full.

4-2.4. Filling the Storage Tank.

4-2.4.1. Filling a Warm Storage Tank. (Refer to Figure 4-1 and Table 4-1). Follow these procedures during the first filling of a tank, filling a tank that has been out of service, or any other time that the inner vessel is at ambient temperature. This will allow the inner vessel to chill evenly, avoiding possible deformation and excessive loss of product.

Table 4-1. Valve Positions and Functions

Valve Symbol	Valve Name	Tank Filling	Pressure Buildup	Liquid Transfer	Drain Gravity	Drain Pressure	Constant Pressure	Liquid Storage	Tank Empty
V-4	Service Line Drain	Closed	Closed	***	Closed	Closed	Closed	Closed	Closed
V-5	Fill/Drain Line Drain	**	Closed	Closed	**	**	Closed	Closed	Closed
V-8	Main Vent Line	Open	Closed	Closed	Open	Closed	Closed	Open	Closed
V-7	Pressurization Buildup	Closed	Open	****	Closed	Optional	Closed	Closed	Closed
V-6	Fill/Drain Shutoff	Open	Closed	Closed	Open	Open	Closed	Closed	Closed
V-3	Service Shutoff	Closed	Closed	Open	Closed	Closed	Closed	Closed	Closed
V-9	Full Trycock	Open	Closed	Closed	Closed	Closed	Closed	Closed	Closed
V-10	LL-1 Isolation	Open	Open	Open	Open	Open	Open	Open	Open

** Opened after transfer operations to drain or vent fill/drain line.
*** Opened after transfer operations to drain or vent service line.
**** Operate as required to maintain transfer pressure.

a. Perform a basic inspection on each storage tank prior to filling. Refer to Section III, paragraph 3-2.3. Remove the dust cap from the 3-inch fill/drain coupling (C-2).

b. Open the vapor vent shutoff valve (V-8) to reduce the tank pressure. Purge the supply hose before connecting to the fill/drain coupling (C-2).

c. Open storage tank fill/drain valve (V-6) and full trycock valve (V-9). Then slightly open the product source service valve, transfer will begin. A large amount of gas will be vented as the entering product cools the inner vessel. Do not exceed 10 psig on storage tank during cool down.

d. Allow the product to enter the tank at a rate such that the pressure on the receiving tank does not exceed 10 psig. Use product source service valve to throttle flow.

e. A large amount of gas will be venting during cooling of the inner vessel. This venting will decrease as the inner vessel reaches the liquid temperature and the source valve can be opened more, however, do not allow receiving tank pressure to exceed 10 psig.

f. When the venting becomes stable, monitor the liquid level gage (LL-1) until the desired level is reached. Do not attempt to exceed the 5000-gallon capacity of the storage tank. As the tank is filled, fluctuating pressures may cause inaccurate display on the liquid level gage (LL-1). Therefore, also observe the full trycock valve (V-9) discharge. If liquid product appears, the storage tank is near, or at, capacity.

g. When the storage tank has been filled to the desired level, close the fill/drain shutoff valve (V-6), the product source supply valve and the full trycock valve (V-9). Immediately open the fill/drain line drain valve (V-5) to relieve the pressure on the hose.

(1) Use extreme caution when disconnecting the supply hose. Do not point it at personnel.

(2) Do not allow extremely cold piping or product to touch the bare skin. Failure to observe these precautions may cause injuries similar to burns.

h. Drain the supply hose at the product source drain valve or by disconnecting the hose.

i. Disconnect the supply hose from the fill/drain coupling (C-2). Loosely reinstall the dust cap on the coupling and close fill/drain valve (V-5) immediately to prevent moisture from entering the line.

j. Leave the vapor vent shutoff valve (V-8) open to allow the tank to stabilize.

4-2.4.2. Filling a Chilled Storage Tank. (Refer to Figure 4-1 and Table 4-1). Use the following procedures when filling a storage tank that is low in product.

a. Perform a basic inspection on each storage tank prior to filling. Refer to Section III, Paragraph 3-2.3.

b. Remove the dust cap from the 3-inch fill/drain coupling assembly (C-2).

c. Purge supply source hose before connecting to fill/drain coupling (C-2).

d. Open the storage tank vapor vent valve (V-8) and full trycock valve (V-9).

e. Open the storage tank fill/drain shut-off valve (V-6).

f. Open the supply source service valve slowly. Transfer will begin.

g. Monitor the liquid level gage (LL-1) until the desired level of product has been reached. Do not attempt to exceed the 5000-gallon capacity of the storage tank. As the tank is filled, fluctuating pressures may cause an inaccurate display on the liquid level gage (LL-1). Therefore, also watch the full trycock valve (V-9) discharge. If liquid product appears, the storage tank is near, or at, capacity.

h. When the storage tank has been filled to the desired level, close the fill/drain valve (V-6), the supply source service valve and the full trycock valve (V-9). Immediately open the fill/drain line drain valve (V-5) to relieve the pressure on the hose.

(1) Use extreme caution when disconnecting the supply hose. Do not point it at personnel.

(2) Do not allow product to touch bare skin. Failure to observe these precautions may cause injuries similar to burns.

i. Drain the supply hose at the supply source drain valve or by disconnecting the hose.

j. Disconnect the supply hose from the fill/drain coupling (C-2). Loosely reinstall the dust cap on the coupling and close fill/drain valve (V-5) immediately to prevent moisture from entering the line.

k. Leave the tank vapor vent shutoff valve (V-8) open and allow the tank to stabilize.

4-2.5. Liquid Transfer from the Storage Tank. (Refer to Figure 4-1 and Table 4-1). Prepare the service cart or other receiving vessel to be serviced by the storage tank in accordance with its applicable Technical Manual.

a. Check the position of all control and gaging valves of the storage tank. The vapor vent shutoff valve (V-8), the fill/drain shutoff valve (V-6), the service line shutoff valve (V-3), service line drain valve (V-4), fill/drain valve (V-5), full trycock valve (V-9), and the pressure buildup valve (V-7) must be closed.

b. Check the quantity of product in the storage tank on the liquid level gage (LL-1). Make sure that sufficient product is available to complete the scheduled transfer. The liquid level gage is most accurate when the vapor vent shutoff valve (V-8) is closed.

c. Uncoil the service line hose from within the control housing.

d. Slowly open the pressure buildup valve (V-7) to raise the tank pressure (50 psig. maximum). Monitor the tank pressure gage (PI-1) as the pressure increases. Close the pressure buildup valve (V-7) in sufficient time to prevent the pressure from rising above 50 psig. Relieve pressure by opening the vapor vent shutoff valve (V-8). Do not allow pressure to exceed 50 psig.

(1) If the receiving vessel is at ambient temperature, it should be chilled before filling.

(2) Follow the applicable directives for the vessel or a procedure similar to that outlined in Paragraph 4-2.4.1.

NOTE

Pressure may increase very rapidly. Pressure buildup is influenced by the vapor space above the liquid in the tank. Pressure will increase after the PBU valve (V-7) is closed until all liquid in the buildup coil has been vaporized.

e. Remove hose cap. Supporting the service hose with heavily gloved hands, slightly open service valve (V-3), and allow a very small amount of product to pass through the hose, purging it of air. Close service valve (V-3).

f. Remove the dust cap from the receiving vessel fill line coupling.

g. Attach the hose to the receiving vessel coupling.

h. Open the fill valve of the receiving vessel.

i. Open the service valve (V-3) slowly. Watch the escaping vapors at the vapor vent of the receiving tank. As the rapid boiling of the product entering the tank diminishes, open the valve fully.

j. Fill the receiving vessel to the desired level.

(1) Use extreme caution when disconnecting a service hose.

(2) Do not point it at personnel. Do not allow product to touch bare skin.

k. Close the storage tank service valve (V-3) and the fill valve of the receiving tank. Immediately relieve the pressure from the hose by manually opening the service line drain valve (V-4). If the receiving tank does not have a drain valve, slowly and carefully uncouple the service hose coupling from the receiving tank.

l. Loosely reinstall the dust cap on the receiving tank fill coupling.

m. If more than one receiving tank is to be filled, retain pressure in the storage tank until all transfers have been made. Close service line drain valve (V-4) and repeat steps a through m for each vessel to be filled.

n. When all liquid transfers have been accomplished, open vapor vent shutoff valve (V-8) to relieve pressure in the storage tank and allow the vapor shutoff valve (V-8) to remain open.

o. When the service hose has been drained, put hose cap on and return it to the control cabinet.

4-2.6. Draining the Storage Tank. (Refer to Figure 4-1 and Table 4-1). If possible, schedule storage tank draining at a time when the liquid level is low. If desired, the process may be speeded by using pressure, using the pressure buildup system as described in Paragraph 4-2.5.

a. Check the storage tank liquid level gage (LL-1) to be sure that a clean suitable vessel of adequate capacity is available to receive the product remaining in the tank.

b. Remove the dust cap from the fill/drain coupling assembly (C-2). Attach one end of a suitable transfer hose to the coupling, and the other end to the inlet of a receiving tank.

c. Prepare the receiving vessel to accept the transferred product in accordance with applicable instructions.

d. Open the storage tank vapor vent valve (V-8); open the fill/drain shutoff valve (V-6). Transfer of the product will begin.

e. When the transfer is complete, close the fill/drain shutoff valve (V-6) and the receiving vessel fill valve. Immediately relieve the pressure from the hose by opening the fill/drain line drain valve (V-5).

(1) Use extreme caution when disconnecting the transfer hose. Do not point it at personnel.

(2) Do not allow product to touch bare skin. Failure to observe these precautions may cause injuries similar to burns.

f. Disconnect the hose from the storage tank and the receiving vessel. Loosely cap all couplings and close fill/drain line drain valve (V-5).

4-2.7. Product Sampling. (Refer to Figure 4-1). Periodically, it will be necessary to obtain samples of the product for testing (Refer to Periodic Inspection Work Cards, T.O. 37C2-8-1-116WC-1) and T.O. 33D2-10-60-1.

NOTE

When purging is indicated by an unsatisfactory product sample (as indicated by T.O. 42B7-3-1-1 or T.O. 42B6-1-1), refer to T.O. 37C2-8-36-3 for purging procedures.

SECTION V

MAINTENANCE INSTRUCTIONS

5-1. SCOPE.

Maintenance instructions pertaining to the removal and replacement of component parts, inspection procedures, troubleshooting techniques, preventative maintenance practices, and specialized testing are covered in this section.

5-2. OPERATIONAL CHECKOUT.

The operational checkout should be performed any time it is necessary to insure the system meets operational performance standards. This checkout is usually performed after maintenance procedures involve a need for purging and/or functional components are replaced. When performing the maintenance procedure, be certain that the complete procedure has been performed. The operational checkout consists of the following procedures:

a. Ensure all required removal, repair, cleaning, replacement, testing, and purging procedures have been performed.

b. Fill the storage tank in accordance with procedures in paragraph 4-2.4.

c. Transfer liquid product from the storage tank in accordance with procedures in paragraph 4-2.5 or 4-2.6.

5-3. INSPECTION AND GENERAL MAINTENANCE INSTRUCTIONS.

5-3.1. Periodic Inspection. Refer to T.O. 37C2-8-1-116WC-1 (Inspection Work Cards).

5-3.2. Periodic Lubrication. No periodic lubrication is required for the storage tank.

5-3.3. General Maintenance Instructions. Maintenance personnel must keep all parts used in handling liquid oxygen free from hydrocarbons. All parts that are removed or left exposed on the tank must be sealed in polyethylene bags until reassembly. All anti-seize tape must be removed and replaced on threaded parts. When replacing anti-seize tape start with the third thread from the end.

5-4. TROUBLESHOOTING.

Refer to Table 5-1 for troubleshooting procedures for common malfunctions, with probable causes and remedies. Component references are to Figure 4-1.

5-5. REMOVAL AND REPLACEMENT OF LINE COMPONENTS.

5-5.1. Fill/Drain Line Filter (F-2). (See Figure 5-1)

a. Open the main cabinet door. This will expose the filters and the associated piping.

b. Make sure that the fill/drain valve (V-6) is tightly closed and that any remaining liquid in the fill/drain line is drained through the fill/drain line drain valve (V-5).

c. Remove valve handles from all valves except (V-8).

d. Remove valve panel.

e. Remove tube (43) and tricock valve (44).

f. Disconnect flex pipe flange at pipe flange (37).

g. Remove nuts (18), washers (19), and screws (20). Remove bracket (21).

h. Slide adapter (30) onto elbow (31).

i. Remove coupling assembly (26) from elbow (31). Slide adapter (30) off elbow (31).

j. Remove elbow (31) and pipe (32) from filter (33).

k. Supporting pipe (35) with a suitable wrench to prevent torsion, turn the filter (33) counterclockwise until it is free.

l. Clean filter (33) or dispense the used filter if clogged beyond further use. After installing anti-seize tape on the male connection of the adapter (35), install the filter. Make sure that the flow-indicating arrow on the filter is pointed towards the fill/drain valve (V-6). Tighten the filter (turning clockwise) until threaded to a depth of approximately 11/16-inch.

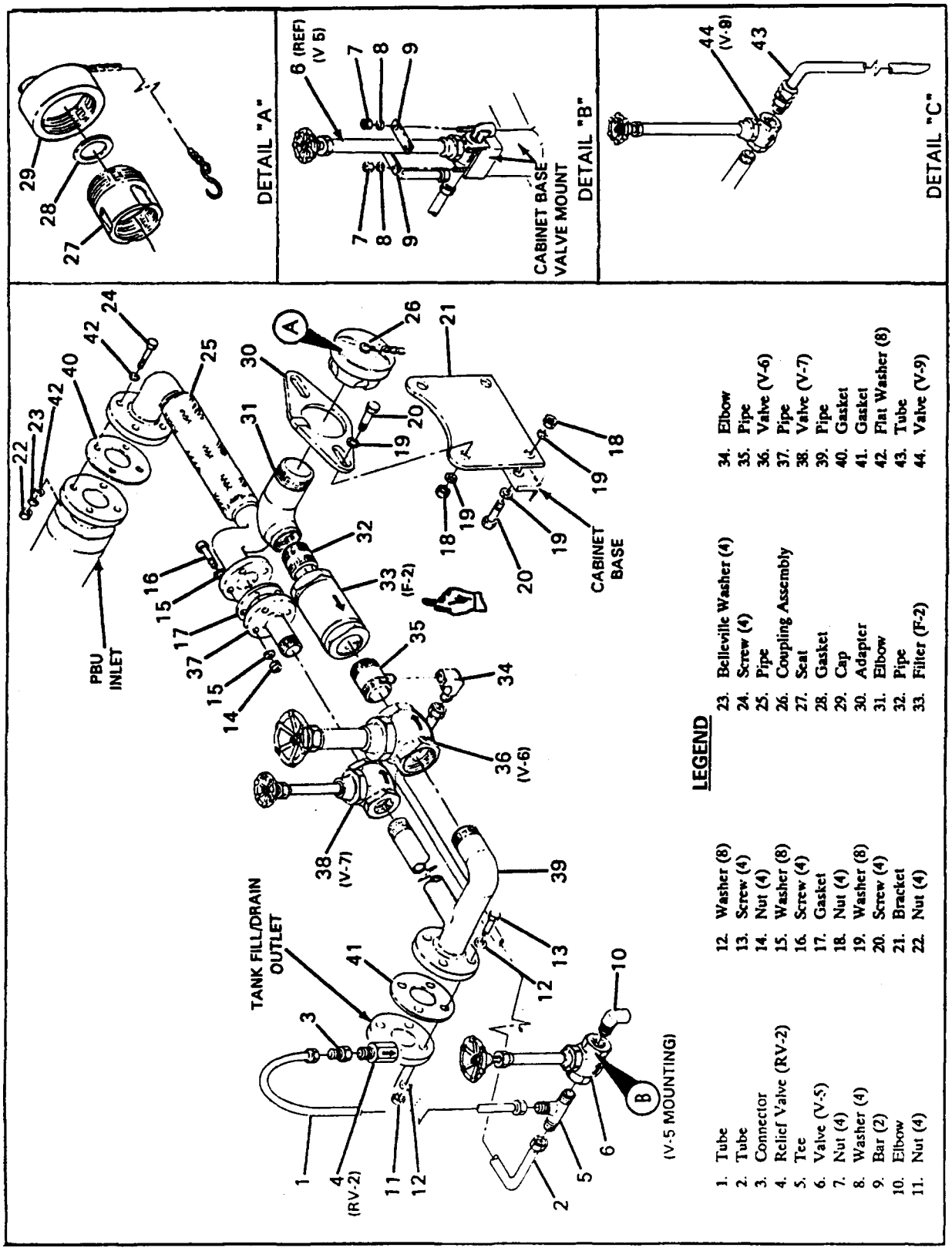


Figure 5-1. Fill/Drain Line

m. Place anti-seize tape on the threads of pipe (35) and install it on the filter. Turn the pipe clockwise until it is threaded to a depth of approximately 11/16-inch. Install elbow (31) on pipe (32).

n. Slide adapter (30) over elbow (31).

o. Place anti-seize tape on the outboard threads of the pipe (32), and install coupling assembly (26) on the nipple. Turn the coupling assembly clockwise until it is threaded to a depth of approximately 11/16-inch. Wrench notch to be at top dead center.

p. Install tricock valve (44), gage panel, and valve handles, connect flex pipe flange to pipe flange (37).

q. Install fill/drain line bracket (21) and secure with screws (20), washers (19) and nuts (18). Align notches in coupling assembly (21) with notches in adapter (30) and secure to frame with screws (20), washers (19) and nuts (18).

r. Leak-test the threaded joints as follows:

(1) Plug coupling assembly (26) using an appropriate plug.

(2) Pressurize the pipe assembly, tricock valve and flex flange to 50 psig.

(3) Using Leak Detection Compound, Oxygen Systems, Type 1 (MIL-L-25567), test the threaded connections on piping, tricock valve and flex flanged joint (37) for leaks, following the instructions enclosed with the Compound.

(4) If a leak is discovered, relieve the pressure in the system. Then, disassemble the piping to remove the leaking part or tighten the leaking joint. Reassemble the hose and piping carefully. Then, continue the leak testing until all leaks have been located and repaired.

(5) When the leak test is finished, relieve the pressure in the system.

(6) Remove the pressure plug from the service coupling assembly and reinstall the coupling dust cover and loop the service line hose over its support bracket. Close fill/drain line vent valve (V-5).

s. Close the main cabinet door.

5-5.2. Service Line Filter (F-1). (See Figure 5-2)

a. Open the main cabinet door. This will expose the filter and associated piping.

b. Make sure that the service line shutoff valve (V-3) is tightly closed and that any remaining liquid in the service line is drained through the service line drain valve (V-4).

c. Remove nuts (4), washers (5) and screws (6). Remove bracket (7).

d. Slide adapter (12) onto nipple (21).

e. Remove coupling assembly (8) from nipple (21). Slide adapter (12) off nipple (21).

f. Unscrew tube nut on tube (18) from elbow (20) and remove elbow.

g. Turn the nipple (21) counter-clockwise until it is free of the filter (22).

h. Supporting the adapter (23) with a suitable wrench to prevent torsion, turn the filter (22) counter-clockwise until it is free.

i. Clean filter (22) or dispense the used filter if clogged beyond further use. After installing anti-seize tape on the male connection of the adapter (23), install the filter. Make sure that the flow-indicating arrow on the filter is pointed away from the service valve (V-3). Tighten the filter (turning clockwise) until threaded to a depth of approximately 11/16-inch.

j. Place anti-seize tape on the threads of nipple (21) and install it on the filter. Turn the nipple clockwise until it is threaded to a depth of

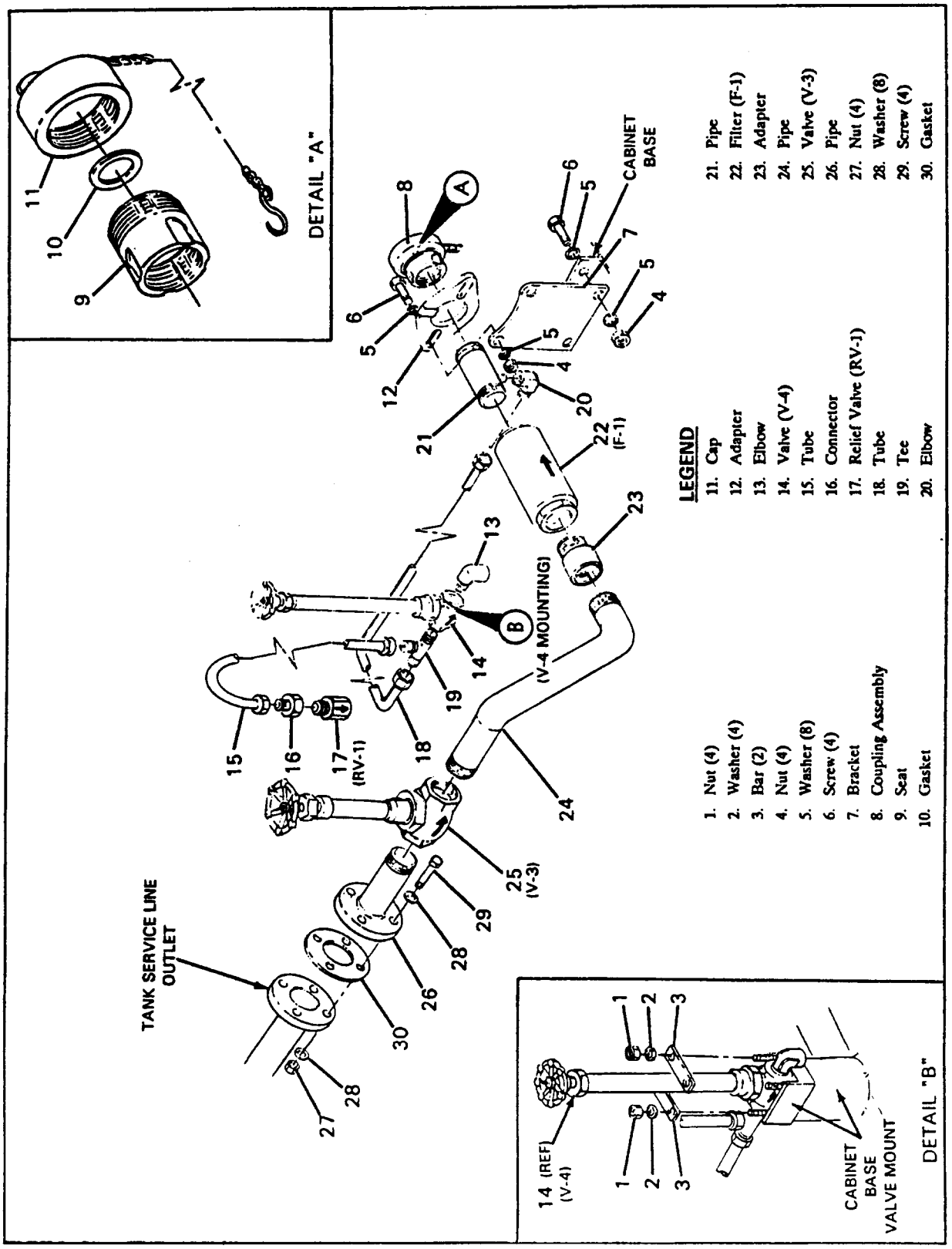


Figure 5-2. Service Line

approximately 11/16-inch. Make sure that the vent line is aligned to match vent line coupling and connect elbow (20) to nipple (21). Screw tube nut on tube (18) onto elbow (20).

k. Slide adapter (12) over nipple (21).

l. Place anti-seize tape on the outboard threads of the nipple (21), and install coupling assembly (8) on the nipple. Turn the coupling assembly clockwise until it is threaded to a depth of approximately 11/16-inch. Wrench notch to be on top dead center.

m. Install service line bracket (7) and secure with screws (6), washers (5) and nuts (4). Align notches in coupling assembly (8) with notches in adapter (12) and secure to frame with screws (6), washers (5) and nuts (4).

n. Leak-test the threaded joints as follows:

(1) Cap coupling using appropriate plug.

(2) Pressurize elbow, nipple assembly, and filter to 50 psig.

(3) Using Leak Detection Compound, Oxygen Systems, Type 1 (MIL-L-25567), test the threaded connections for leaks, following the instructions enclosed with the Compound.

(4) If a leak is discovered, relieve the pressure in the system. Then, disassemble the piping to remove the leaking part or tighten the leaking joint. Reassemble the hose and piping carefully. Then, continue the leak testing until all leaks have been located and repaired.

(5) When the leak test is finished, relieve the pressure in the system.

(6) Remove the pressure plug fitting from the service coupling. Reinstall the service hose and loop the hose over the support bracket. Close service line vent valve (V-4).

o. Close the main cabinet door.

5-5.3. Inner Shell Rupture Disc. (See 2, Figure 4-1)

a. Open the main cabinet door. This will expose the rupture disc holder.

b. Separate the rupture disc holder and remove rupture disc from holder. Observe the position of the disc.

c. Install the new rupture disc in holder in the same position of old disc.

d. Screw the rupture disc holder together.

5-5.4. Fill/Drain Line Vent Valve (V-5). (See Figure 5-1)

a. Open the main cabinet door. This will expose the valves and associated piping.

b. Remove elbow (10) from valve (6).

c. Remove four nuts (7) and washers (8) from the two bars (9). Remove bars (9).

d. Remove bonnet and stem assembly from valve (6).

e. Unscrew valve (6) body from tee (5) and remove it from cabinet base.

f. Remove bonnet and stem assembly from new valve.

g. Connect new valve (6) body to tee (5) and install it on cabinet base.

h. Install bonnet and stem assembly on new valve (6) body.

i. Secure valve (6) to cabinet base with two bars (9), four washers (8) and nuts (7).

j. Install elbow (10) on valve (6).

k. Close fill/drain line vent valve (V-5).

l. Close main cabinet door.

5-5.5. Fill/Drain Line Relief Valve (RV-2). (See Figure 5-1)

a. Open the main cabinet door. This will expose the valves and associated piping.

b. Unscrew relief valve (4) from connector (3).

c. Screw new relief valve (4) onto connector (3).

d. Close main cabinet door.

5-5.6. Service Line Vent Valve (V-4). (See Figure 5-2)

a. Open the main cabinet door. This will expose the valves and associated piping.

b. Remove elbow (13) from valve (14).

c. Remove four nuts (1) and washers (2) from the two bars (3). Remove bars (3).

d. Remove bonnet and stem assembly from valve (14).

e. Unscrew valve (14) body from tee (19) and remove it from cabinet base.

f. Remove bonnet and stem assembly from new valve.

g. Connect new valve (14) body to tee (19) and install it on cabinet base.

h. Install bonnet and stem assembly on new valve (14) body.

i. Secure valve (14) to cabinet base with two bars (3), four washers (2) and nuts (1).

j. Install elbow (13) on valve (14).

k. Close service line vent valve (V-4).

l. Close main cabinet door.

5-5.7. Service Line Relief Valve (RV-1). (See Figure 5-2)

a. Open the main cabinet door. This will expose the valves and associated piping.

b. Unscrew relief valve (17) from connector (16).

c. Screw new relief valve (17) onto connector (16).

d. Close main cabinet door.

5-5.8. Liquid Level Gage (LL-1). (See Figure 5-3)

a. Open the main cabinet door. This will expose the gage.

b. Close isolation valve (V-10). Verify that there is no pressure on tank.

c. Disconnect tube (9) from elbow (14).

d. Disconnect tube (7) from elbow (15).

e. Remove elbows (14 and 15) from gage (16).

f. Remove three screws (24) and remove cover (25) from gage (16).

g. Remove four screws (27) and nuts (26) and remove gage (16) from panel (32).

h. Install new gage (16) on panel (32) and secure with four screws (27) and nuts (26).

i. Install cover (25) on gage and secure with three screws (24).

j. Install elbows (14 and 15) on gage.

k. Connect tubes (7 and 9) to elbows (14 and 15).

l. Open isolation valve (V-10).

m. Close the main cabinet door.

5-5.9. Tank Pressure Gage (PI-1). (See Figure 5-3)

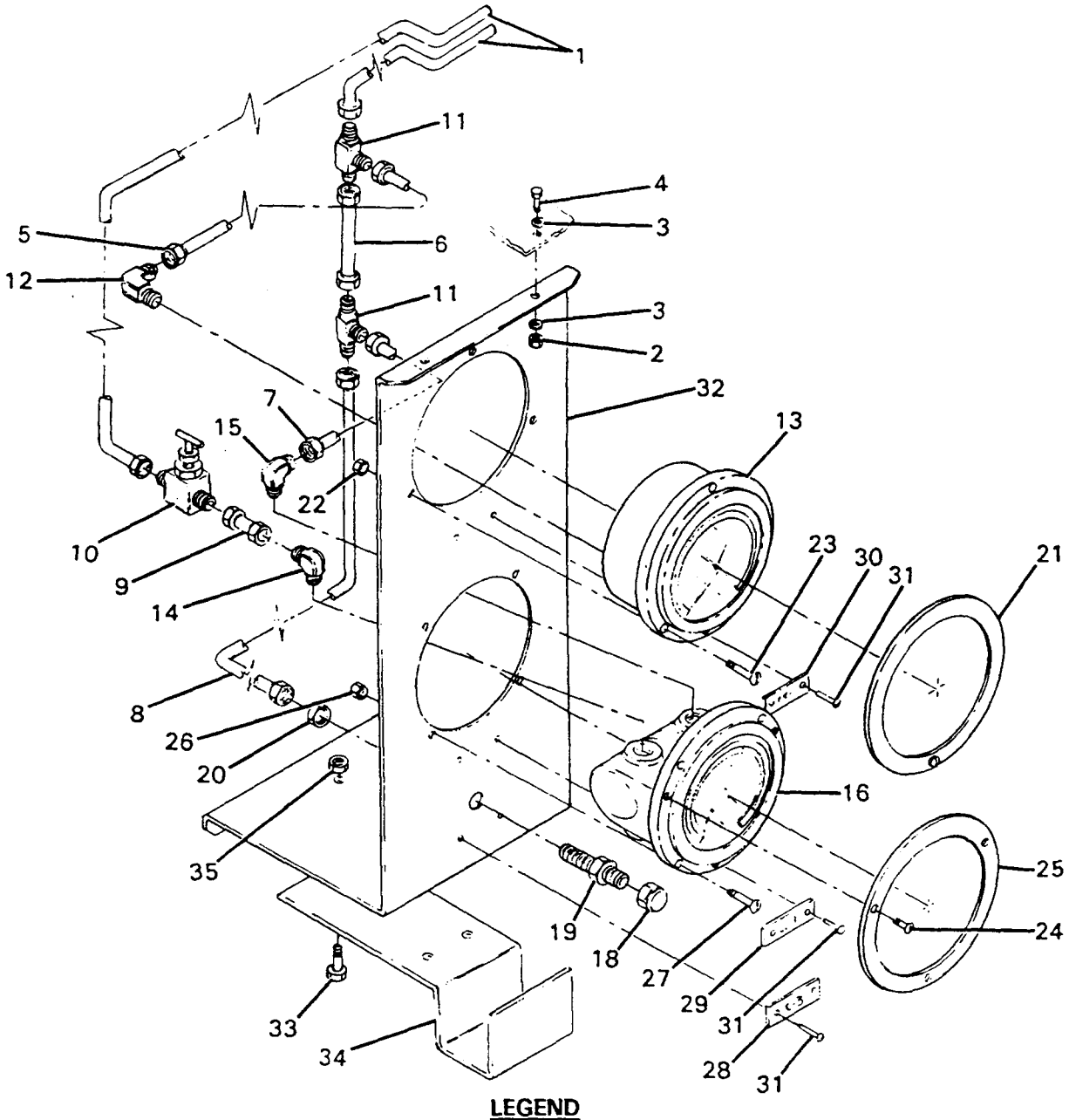
a. Open the main cabinet door. This will expose the gage.

b. Verify that there is no pressure on the tank. Disconnect tube (5) from elbow (12).

c. Remove elbow (12) from gage (13).

d. Remove cover (21) from gage (13).

e. Remove three screws (23) and nuts (22) and remove gage (13) from panel (32).



LEGEND

1. Tube (2)
2. Nut (4)
3. Washer (8)
4. Screw (4)
5. Tube
6. Tube
7. Tube
8. Tube
9. Tube
10. Valve (V-10)
11. Tee (2)
12. Elbow
13. Pressure Gage (PI-1)
14. Elbow
15. Elbow
16. Liquid Level Gage (LL-1)
17. (Deleted)
18. Cap
19. Union
20. Locknut
21. Cover
22. Nut (3)
23. Screw (3)
24. Screw (3)
25. Cover
26. Nut (4)
27. Screw (4)
28. Nameplate
29. Nameplate
30. Nameplate
31. Rivet (6)
32. Panel
33. Screw (3)
34. Bracket
35. Nut (3)

Figure 5-3. Instrument Panel

f. Install new gage (13) on panel (32) and secure with three screws (23) and nuts (22).

g. Install cover (21) on gage (13).

h. Install elbow (12) on gage (13) and connect tube (5) to elbow (12).

i. Close the main cabinet door.

5-6. CLEANING.

5-6.1. Interior. The interior of the storage tank must be cleaned whenever any contaminants are evident or whenever the inner tank or lines have been repaired. The cleaning process is referred to as purging. Purging is the process of forcing heated air or nitrogen through the drained storage tank to expell the contaminants. Refer to T.O. 37C2-8-36-3 for purging procedures.

5-6.2. Exterior. Clean the external surfaces of the storage tank and exposed surfaces inside the control housing with a mild detergent and warm water. Do not use extremely hot water or steam.

5-6.3. Separately Cleaned Parts. Parts that are disassembled for repair, inspection, replacement, or cleaning must be cleaned separate from the storage tank. Refer to T.O. 37C2-8-36-3 for cleaning procedures.

5-7. TANK TESTING.

5-7.1. Vacuum Efficiency Test Procedure. (See Figure 5-4 and 5-5)

This is the basic procedure. For detailed instructions, refer to T.O. 37C11-3-1 (Vacuum Gage, Portable, Part No. 15840) or use Efficiency Meter, NSN 6685-01-117-9931YD, Part No. 50C-0016-2.

a. Open the main cabinet door.

b. Attach a portable thermocouple (vacuum) gage (Refer to Table 2-1) receptacle to the thermocouple tube (VI-1) as shown in Figure 5-4.

c. Open the vacuum thermocouple valve (V-2), and allow the system to stabilize for two minutes before proceeding.

d. Switch the thermocouple gage to ON, and read to determine the annulus vacuum level. The annulus vacuum in a warm tank should be less than 10 microns. If the indication is greater than 35 microns, the storage tank must be evacuated. (Refer to T.O. 37C2-8-36-3 for procedure.) The indications for a chilled tank will be substantially lower.

e. After the reading has been completed and recorded, close the vacuum indicator valve (V-2), and set the thermocouple gage switch to off. To avoid vacuum loss, make sure that the vacuum thermocouple valve (V-2) is tightly closed at all times, except when actually measuring vacuum.

f. Disconnect the thermocouple gage receptacle from the thermocouple tube (VI-1).

g. Close the main cabinet door.

h. Vacuum Efficiency Test Procedure (See Figure 5-5). The use of the Dual Efficiency Meter is recommended, if available, in lieu of the portable vacuum gage for determining the efficiency of the tank vacuum. For basic procedures for the Dual Efficiency Meter refer to T.O. 37C2-8-27-11.

5-8. VACUUM SYSTEM MAINTENANCE.

The efficiency of the storage tank depends on the vacuum in the annular space (between the inner and outer tanks). The vacuum may be lost by leaks, gas diffusion or contamination. As it is impossible to maintain a perfect vacuum, some loss of vacuum level may be expected as time passes. It is, therefore, very important to maintain records of vacuum level. A slow deterioration of vacuum as shown in the records will indicate normal loss; and, that a simple evacuation (pump-down) is required rather than extensive repairs.

5-8.1. Evidence and Effects of Vacuum Loss. The outward indications of vacuum loss are:

a. A visible and abnormal amount of vapor escaping from the vapor vent.

b. Severe weight loss while product is in storage.

c. High pressure in the inner vessel whenever the vapor vent valve (V-8) is closed. This will cause a constant relieving of the pressure relief

valve (RV-3).

d. A cold, sweating outer jacket.

e. Failure of the regular vacuum efficiency test required by T.O. 37C2-8-1-116WC-1 (Periodic Inspection Work Cards). A procedure for performing this test is outlined in Paragraph 5-7.1.

5-8.2. Repair Procedures. Determination of the cause of the loss may be very difficult. The tools and equipment for detailed leak detection are not available at the base level. However, every attempt must be made to find the cause, as this will determine the agency that will make the repairs. (Losses due to leaks or contamination are beyond the capabilities of base repair.)

a. When the repair requirements have been determined, depot assistance will be requested according to T.O. 00-25-107.

b. The request for depot assistance will include a description of all deficiencies of the storage tank, and a detailed repair cost estimated reported on AFTO Form 375. Instructions for preparing the AFTO 375 Form are contained in T.O. 35-1-24.

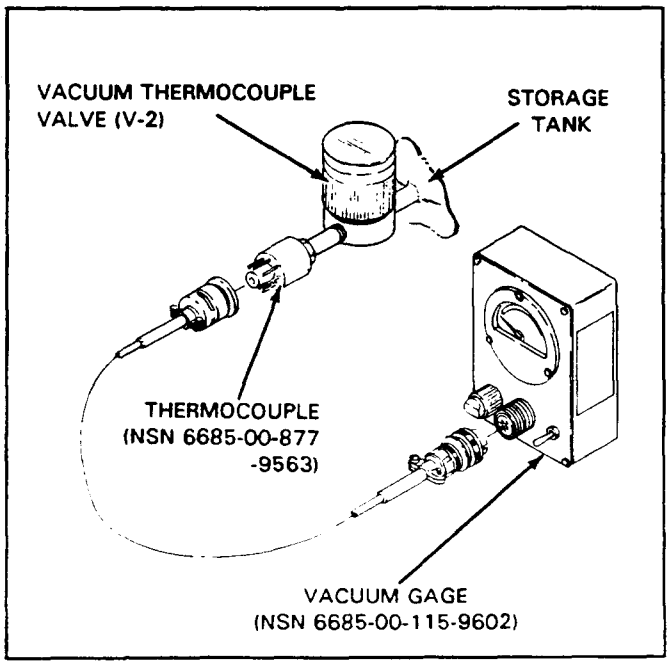


Figure 5-4. Gage, Vacuum

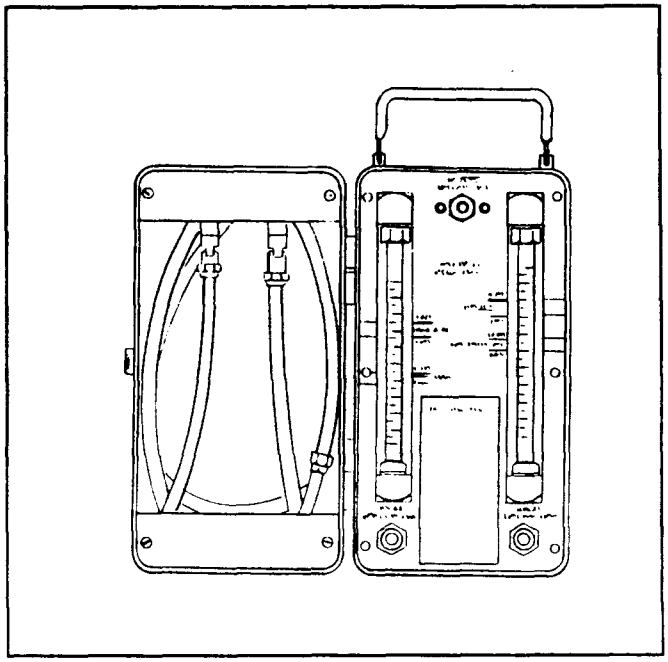


Figure 5-5. Meter, Dual Efficiency

Table 5-1. Troubleshooting Procedures

Trouble	Probable Cause	Remedy
a. Low flow rate through service hose	Low tank pressure	Raise tank pressure to 50 psig. (Para. 4-2.5) or see h below.
	Clogged filter (F-1)	Remove and replace filter (Para. 5-5.2).
	Service valve (V-3) is partially closed.	Open valve fully, also see below.
	Ice or contaminated product in ports, valves or hose.	Check for and dispose of ice or contaminated product.
b. Low flow rate through fill/ drain line	Clogged filter (F-2).	Remove and replace (Para. 5-5.1.).
	Fill/drain valve (V-6) partially closed.	Open valve fully, also see below.
c. Liquid level gage oscillates	Leak in gage line from tank to gage, or an obstruction in the line.	Check for leaks in gage line. Repair or remove obstruction as necessary.
	Oscillation dampening screw not set	Set screw.
d. Liquid level gage consistently indicates high or low	One of valves at tank is closed.	Check valves for proper positions. Correct.
	Gage needle bent or stuck.	Tap gage slightly. Inspect needle for bends. Repair or condemn as necessary.
	Gage damaged or out of adjustment or calibration.	Replace. Return to depot for calibration.
	Leaking gage line.	Inspect for leaks, repair as appropriate. Also see below.
e. Liquid level or pressure gage not operating.	Ice or foreign material clogging lines or bellows.	Disconnect line. Clean or thaw as necessary.
f. Frozen valve	Moisture in stem packing.	Thaw and dry valve with hot, dry nitrogen gas. Tighten packing nut.
g. Frost on top of valve stem, extending to top.	Loose packing gland nut on valve stem.	Tighten packing gland nut.

Table 5-1 Troubleshooting Procedures--Cont.

Trouble	Probable Cause	Remedy
h. Valve leaking vapor and liquid.	Foreign material or ice on valve seat.	Drain tank (Para. 4-2.6). Disassemble valve (See T.O. 37C2-8-36-3); replace seat.
	Valve seat worn, broken or missing.	Drain Tank (Para. 4-2.6). Disassemble valve (See T.O. 37C2-8-36-3); replace seat.
i. Valve fails to pass product or gas.	Defective or clogged valve.	Inspect valve. Open and close it several times to check operation. Refer to T.O. 37C2-8-36-3 for disassembly, repair and replacement procedures.
j. Tank will not build or maintain pressure with the pressure build-up valve (V-7) open.	Line to pressure buildup coil clogged.	Clear obstruction from line.
	Faulty pressure buildup valve.	See f. and i. above.
	Relief valve leaking, frozen open, or opening too soon.	See f. and h. above.
	Rupture disc has burst.	Replace rupture disc. (Para. 5-5.3)
	Low liquid level.	Fill storage tank.
	Leaks to atmosphere.	Locate leaks. Repair if authorized.
	Malfunction of pressure gage, faulty indication.	Check pressure gage. Replace if necessary.
k. Excessive tank pressure.	Over-filling of tank.	Drain excess product. (Para. 4-2.6)
	Low liquid level causes rapid pressure rise.	Fill storage tank.
	Loss of annulus vacuum.	Check vacuum level (Para. 5-7.1). Evacuate annulus (T.O. 37C2-8-36-3).
l. Loss of annulus vacuum.	Normal deterioration of vacuum.	Check vacuum level (Para. 5-7.1). Evacuate annulus (T.O. 37C2-8-36-3).
	Leaks to atmosphere.	Check for leaks at outer shell relief valve, outer vessel, where piping enters vessels, vacuum seal-off valve, etc.

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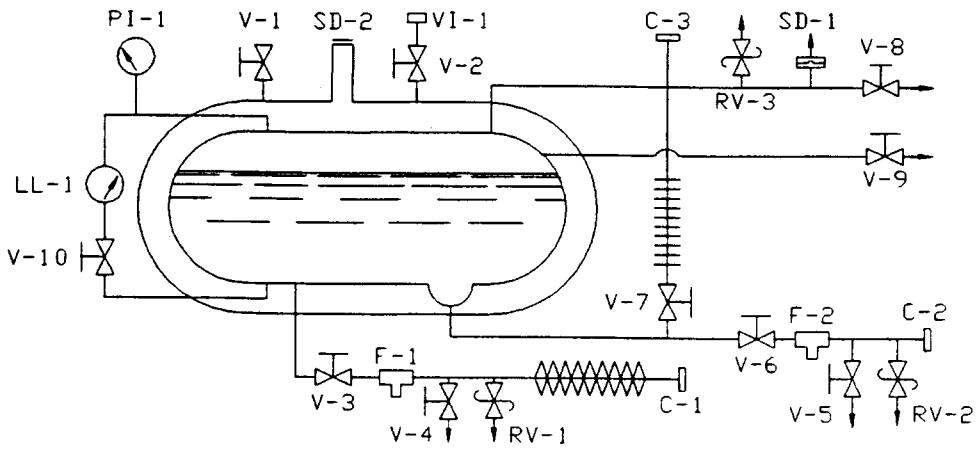
Table 5-1 Troubleshooting Procedures--Cont.

Trouble	Probable Cause	Remedy
	Leaks at thermocouple (VI-1), vacuum gage valve (V-2), or vacuum line shutoff valve (V-1).	Make sure that valve is closed, and threaded connections are sealed. Replace components, if necessary. Evacuate per T.O. 37C2-8-36-3.
m. Failure to attain vacuum during evacuation	Incorrect reading of vacuum gage.	Read gage again.
	Leaks in vacuum pump, hose or equipment.	Locate and repair leaks.
	Defective gage.	Replace gage with one of known accuracy.
	Undetected leak in storage tank.	Locate and repair.
	Defective pump.	Replace pump with one of known performance.
	Moisture in pump lubricant.	Drain and replace lubricant.
	Moisture in pump.	Open pump ballast valve, allow water to drain.

SECTION VI
DIAGRAMS

6-1. FLOW SCHEMATIC DIAGRAM (See Figure 6-1).

Figure 6-1, Storage Tank Flow Schematic Diagram is included to assist in a greater understanding of the operation of the storage tank.



LEGEND

C-1	COUPLING-SERVICE LINE	V-1	VALVE-EVACUATION
C-2	COUPLING-FILL/DRAIN LINE	V-2	VALVE-ISOLATION (VI-1)
C-3	COUPLING-EXTERNAL PRESSURE	V-3	VALVE-SERVICE LINE
F-1	FILTER-SERVICE LINE	V-4	VALVE-SERVICE LINE VENT
F-2	FILTER-FILL/DRAIN LINE	V-5	VALVE-FILL/DRAIN LINE VENT
LL-1	LIQUID LEVEL GAUGE	V-6	VALVE-FILL/DRAIN LINE
PI-1	PRESSURE INDICATOR-VAPOR PHASE	V-7	VALVE-PRESSURE BUILDUP
RV-1	RELIEF VALVE-SERVICE LINE	V-8	VALVE-VAPOR VENT LINE
RV-2	RELIEF VALVE-FILL/DRAIN LINE	V-9	VALVE-FULL TRYCOCK
RV-3	RELIEF VALVE-INNER SHELL	V-10	VALVE-ISOLATION,LL-1
SD-1	SAFETY HEAD-INNER VESSEL	VI-1	VACUUM INDICATOR
SD-2	SAFETY HEAD-OUTER VESSEL		

Figure 6-1. Storage Tank Flow Schematic Diagram.

SECTION VII
ILLUSTRATED PARTS BREAKDOWN

7-1. ILLUSTRATED PARTS BREAKDOWN.

The Illustrated Parts Breakdown for the storage tank is contained in T.O. 37C2-8-36-4.

SECTION VIII
DIFFERENCE DATA SHEETS

Not Applicable

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